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(54) Modular jack with anti-cross-talk contacts and method of making same

(57) The connector comprises a plurality of conductors (1 - 8) arranged in an array within a housing, with the conductors each having a contact area (20) that lies within a first plane. A first plurality of the conductors (1,3,5,7) each having a raised portion (22), and a second plurality of conductors (2,4,6,8) each have a lower portion (23). The raised portions (22) lie within a second plane, and the lower portions (23) lie within a third plane, where the first, second and third planes are vertically spaced, or offset, from one another. Additionally, the raised portion (22) and/or lower portion (23) of any conductor (1 - 8) may be laterally offset from one another.

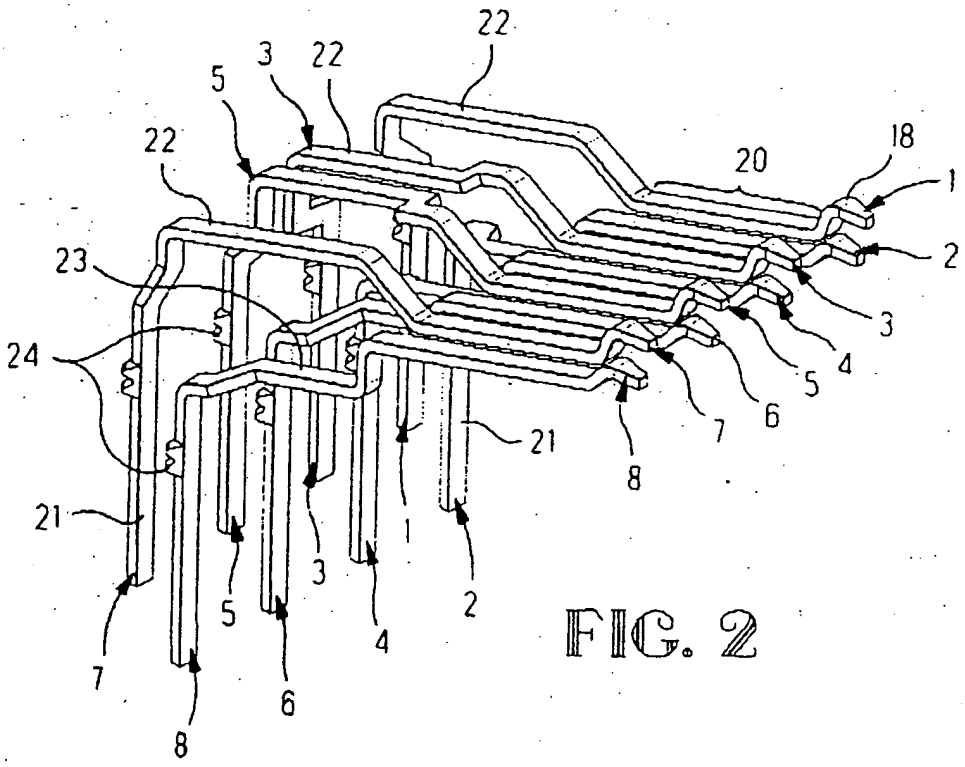

FIG. 2

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Description

[0001] The present inv ntion is directed to an electrical connector, and, more particularly to an electrical connector for reducing cross-talk and a method of making same.

[0002] Cross-talk can be generally described as the unwanted coupling of electrical signals on adjacent signal lines. Such cross-talk may result in portions of an electrical signal on one pair of lines appearing on a separate pair of lines as unwanted noise.

[0003] Cross-talk between different pairs of wires is a source of interference that can cause signal degradation and negatively impact the ability of a communication system to process incoming signals. Cross-talk can also increase error rates and reduce signal strength.

[0004] Problems associated with unwanted cross-talk are becoming even more problematic given the general increase in operating frequencies and data rates of modern communication systems. Additionally, cross-talk can be particularly problematic within electrical connectors that contain a plurality of circuits that are generally parallel and spaced closely together -- a configuration that may lead to excessive cross-talk even over short conductor lengths.

[0005] The present invention is directed to an electrical connector that solves or reduces some or all of the aforementioned problems.

[0006] The connector is comprised of a plurality of conductors positioned within a housing. The conductors have a contact area adapted for mating electrical engagement with a mating plug. The contact areas of the conductors are positioned in a first horizontal plane. A first group of the conductors also each have a raised portion, the raised portions of these conductors lies in a second horizontal plane that is vertically displaced from the first horizontal plane containing the contact areas of the conductors. The connector may also include a second group of conductors in which a portion of each of the conductors lies in a horizontal plane that is vertically displaced from the first and second horizontal planes discussed above.

[0007] The present invention is also directed to a method of manufacturing an electrical connector. The method comprises the step of forming a first plurality of conductors to have a contact area and a raised portion. The method further comprises positioning the first plurality of conductors within a connector housing such that the contact area of at l ast one of said first plurality of conductors is located in a first plane and the raised portion of the connector is located in a second plane, the first and second planes being offset from one another.

[0008] The invention may be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals identify like elements, and in which:

Figures 1 and 1A are exploded, front and rear isometric views of the present invention;
Figures 2 and 3 are isometric upper and lower views of the electrical conductor array of the present invention; and
Figures 4 and 5 are plan and elevation views of the conductor array of Figures 1 to 3.

[0009] With reference to Figures 1, 1A and 2, the electrical connector 10 is generally comprised of an outer shield 12, a plastic housing 14, and a plurality of conductors 1-8. Each of the conductors 1-8 is associated with a particular signal line or wire. Electrical signals are transmitted over pairs of wires to contacts within a plug connector matable with connector 10. According to industry standards, the particular wires that are paired together are 1-2, 3-6, 4-5, and 7-8. While the present invention is illustrated using eight conductors, it is envisioned that the number of conductors could be varied to include more or less without departing from the spirit and scope of the invention.

[0010] Each of the conductors 1-8 is comprised of a tip 18, a contact area 20, a leg portion 21, and two retention barbs 24. The conductors 1,3,5,7 also have a raised portion 22 between contact area 20 and leg portion 21. The conductors 2,4,6,8 also have a lower portion 23 between contact area 20 and leg portion 21. As can be seen in Figures 2, 3 and 5, the tips 18 of the conductors 1,3,5,7 diverge vertically from the tips 18 of the conductors 2,4,6,8.

[0011] The contact area 20 of the conductors 1-8 is adapted for electrical engagement with electrical contacts on a plug (not shown) that is to be inserted into the completed electrical connector. The contact area 20 of the conductors 1-8 is generally located in a first plane. In one embodiment, the raised portions 22 of the conductors 1,3,5,7 and the lower portions 23 of the conductors 2,4,6,8 are also located in separate second and third planes. The planes containing the raised portions 22 and lower portions 23 of the conductors are vertically spaced, or offset, from the plane containing the contact areas 20 of the electrical conductors 1-8.

[0012] As can be s en in Figures 1, 2 and 5, the raised portions 22 of conductors 3 and 5 are spaced horizontally closer together. Of course, it should be understood that it is not necessary for the raised portions 23 of conductors 3 and 5 to xtend sid -by-sid for th full axial length of their raised portions in order to accomplish th objectives of th present invention. Additionally, as can be seen in Figure 3, the lower portion 23 of the conductor 6 is spac d horizontally closer to the lower portion 23 of conductor 4. The downwardly depending legs 21 of the electrical conductors 1-8 are configured in two rows in a standard footprint for insertion into, for example, a printed circuit board (not shown).

[0013] The conductors 1-8 are adapted for insertion into housing 14. In particular, the conductors 1-8 are retained

in recesses 30 formed in housing 14, by the two retention barbs 24 on each of the legs 21 of the conductors 1-8. Additionally, the tip 18 of each of the conductors is adapted for mechanical engagement with recesses (not shown) in the housing 14. After the electrical conductors 1-8 are inserted into the housing 14, the outer shield 12 is positioned over and secured to the housing 14. The outer shell 12 is generally comprised of body 40, rear panel 41, ground tabs 42, and panel ground tabs 44. After housing 14 is inserted into outer shell 12, rear panel 41 is folded down until clips on rear panel 41 engage recesses 45 in the outer shell 12. The completed electrical connector is attached to, for example, a printed circuit board by means of tabs 32.

[0014] The electrical conductors 1-8 are .475 mm wide, 0.25 mm thick, and are manufactured from phosphorous bronze. Of course, the particular cross-sectional area of the conductors 1-8 may be configured in any manner, for example, circular, without departing from the spirit of the present invention. The contact area 20 of electrical conductors 1-8 is approximately 5 mm long, and the centerline spacing between the electrical conductors 1-8 in the contact area 20 is approximately 1.02 mm. The second plane containing the raised portions 22 of conductors 1,3,5,7 is offset approximately 1.24 mm above the plane containing the contact areas 20 of the conductors 1-8, and offset approximately 2.36 mm above the plane containing the lower portions 23 of conductors 2,4,6,8. The raised portions 22 of conductors 1,3,5,7 are approximately 5.59 mm in length. The lower portions 23 of conductors 2,4,6,8 are approximately 4.06 mm in length. The length of the portions of conductors 1,3,5,7 extending between the contact area 20 and the raised portions is approximately 1.45 mm. The length of the portion of conductors 2,4,6,8 extending between the contact areas 20 and the lower portions 23 is approximately 0.64 mm. The centerline spacing between the raised portions 22 of conductors 3 and 5 is approximately 1.04 mm. The centerline spacing between the raised portions 22 of conductors 1 and 3 and between the raised portions 22 of conductors 5 and 7 is approximately 2.5 mm. The centerline spacing between the lower portions 23 of conductors 6 and 4 is approximately 1.04 mm. The centerline spacing between the lower portions 23 of conductors 2 and 4 and the lower portions 23 of conductors 6 and 8 is approximately 2.03 mm and 3.01 mm, respectively, while that of conductors 4 and 6 is approximately 1.04 mm, since lower portion 23 of conductor 6 is laterally offset from its contact area 20 by approximately 0.98 mm.

[0015] A method of manufacturing a connector of the present invention comprises the following steps: forming a first plurality of conductors that each have a contact area 20 and a raised portion 22; positioning at least one of said first plurality of conductors such that the contact area 20 of the conductor lies in a first plane and the raised portion 22 of the conductor lies in a second plane, the first and second planes being vertically spaced, or offset, from one another; and positioning the conductors in an electrical connector housing 14.

[0016] The inventive method disclosed herein further comprises the following steps: forming a second plurality of conductors that have a contact area 20 and a lower portion 23; positioning at least one of said second plurality of conductors such that the contact area 20 lies in the first plane referenced above and the lower portion 23 lies in a third plane, the second and third planes being vertically spaced, or offset, from one another.

[0017] The inventive method also comprises forming at least one of the first plurality of conductors so that the raised portion 22 of the conductor is laterally offset from the contact area of the conductor. The method further comprises forming at least one of the second plurality of conductors such that the contact area 20 is laterally offset from the lower portion 23 of the conductor. As can be seen in Figures 2 and 3, the method includes: forming at least two conductors such that each of the conductors has a contact area 20 and a laterally offset raised portion 22, the contact areas 20 of the conductors lying in a first plane that is vertically spaced from a second plane containing the raised portions 22 of the conductors; forming at least one conductor having a contact area 20 and a laterally offset lower portion 23, the contact area 20 being located in a first plane and the lower portion 23 being located in a third plane; and positioning the conductors into an array in an electrical connector housing such that the first, second and third planes are vertically spaced, or offset, from one another.

[0018] The present invention may be manufactured without the need of using expensive and time-consuming insert molding techniques. The present invention can be made by pre-forming the outer shield 12 and housing 14, by any of a variety of known forming techniques, such as stamping, molding or casting, etc. The conductors 1-8 may be formed by any known technique, such as stamping to the desired shape, etc. Thereafter, the specially configured conductors may be inserted into the rear of the housing 14, either manually or automatically.

[0019] Conductors 1,3,5,7 and 2,4,6,8 may be kept attached to respective carrier strips (not shown) until after the conductors are inserted into the housing, after which the carrier strips are broken off.

[0020] The present invention is effective for reducing unwanted cross-talk. The planes containing the contact areas 20, raised portions 22 and lower portions 23 of the appropriate conductors to break up the parallelism within the electrical connector which, in turn, reduces the overall cross-talk of the electrical connector. Similarly, the tips 18 of the conductors 1-8 are also offset vertically to break up the parallelism of the connector. Of course, as is readily apparent, it is not absolutely necessary that all of the planes containing the contact area 20, raised portions 22 and lower portions 23 of the conductors 1-8 be vertically offset from one another in order to provide a connector that would reduce cross-talk. For example, the plane containing either the raised portions 22 or the lower portions 23 of the conductors could be positioned on the same plane that contains the contact areas 20 of the conductors 1-8.

[0021] Additionally, the configuration of the raised portions 22 of the conductors 3 and 5 and the configuration of lower portion 23 of conductor 6 also act to provide compensating cross-talk that r duces the overall cross-talk of the connector. That is, assuming that conductors 3 and 6 are the driven signal lines, at an initial time, there may be a positive electrical signal on conductor 6 and an equal amplitude, but opposite polarity, negative signal on line 3. In the contact area 20, conductor 6 will couple strongly to conductor 5 which will result in conductor 5 picking up some of the positive signal then pr sent on conductor 6. In a similar manner, in the contact area 20, conductor 3 will couple strongly to conductor 4 which will result in conductor 4 picking up some of the negative signal then present on conductor 3.

[0022] The raised portion 22 of the conductor 3 is positioned laterally closer to the raised portion 22 of conductor 5 which will result in conductor 5 picking up some of the negative signal then present on line 3. In turn, this negative signal on conductor 5 will act to cancel or reduce the positive cross-talk signal induced on conductor 5 in the contact area 20 due to its proximity to conductor 6. Similarly, the lower portion 23 of conductor 6 is positioned laterally closer to the lower portion 23 of conductor 4, resulting in conductor 4 picking up some of the positive signal then present on conductor 6. In turn, this positive signal on conductor 4 will act to cancel or reduce the negative cross-talk induced on conductor 4 in the contact area 20 due to its proximity to conductor 3.

[0023] Performance testing on the disclosed embodiment of the present invention showed that the electrical connector disclosed herein is effective at reducing cross-talk. The tests were performed by mating the connector to a test plug which was qualified per TIA/EIA 568-A, Section B.2, TOC Test Method. The test plug had a cross-talk reading of 41.4 dB @ 100 MHz. The plug was then driven by a differential sinusoidal signal swept from 1 to 100 MHz, which was applied to the driven pair. The noise coupled from the driven pair to the victim pair was measured and recorded as detailed in the following table:

Driven Pair	Victim Pair	Cross-Talk @ 100 MHz
4&5	3&6	-40.7 dB
3&6	1&2	-48.4 dB
3&6	7&8	-46.3 dB
4&5	7&8	-66.3 dB
1&2	4&5	-66.2 dB
7&8	1&2	-69.4 dB

Claims

1. An electrical connector (10), comprising:

   a housing (14) and a plurality of electrical conductors (1 - 8) positioned within said housing (14), said conductors configured in an array,
   each of said conductors (1 - 8) having a contact area (20), at least some of said contact areas lying in a first plane;
   a first plurality of said conductors (1,3,5,7) each having a raised portion (22) of the conductor lying in a second plane, said second plane being offset from said first plane; and
   a second plurality of said conductors (2,4,6,8) having a lower portion (23) of the conductor lying in a third plane, said third plane being offset from said second plane and said first plane.

2. An electrical connector (10) as set forth in claim 1 wherein said second plane is offset from said first plane by approximately 1.24 mm and said third plane is offset from said first plane by approximately 1.12 mm.

3. An electrical connector (10) as set forth in claim 1 or 2 wherein said first plurality of said conductors (1,3,5,7) each have a contact area (20) extending a first axial length and a raised portion (22) extending a second axial length, said contact area (20) and said raised portion (22) of at least one of said conductors (3,5) being laterally offset from one another.

4. An lectrical connector (10) as set forth in claim 3 wherein centerlines of said contact area (20) and said raised portion (22) of said at least one conductor (3,5) are laterally offset by approximately 0.49 mm.

5. An electrical connector (10) as set forth in claim 3 or 4 wherein said contact areas (20) and said raised portions

(22) of each of at least two of said conductors (3,5) are laterally offset from one another.

6. An electrical connector (10) as set forth in claim 5 wherein centerlines of said contact areas (20) and said raised portions (22) of said at least two conductors (3,5) are laterally offset by approximately 0.49 mm.

7. An electrical connector (10) as set forth in claim 6 wherein centerlines of said raised portions (22) of at least two of said conductors (3,5) are spaced apart approximately 1.04 mm for at least some portion of the axial length of said two conductors.

8. An electrical connector (10) as set forth in any preceding claim wherein said second plurality of conductors (2,4,6,8) each have a contact area (20) extending a first axial length and a lower portion (23) extending a second axial length, said contact area (20) and said lower portion (23) of at least one of said conductors (2,6) being laterally offset from one another.

9. An electrical connector as set forth in claim 8 wherein said contact area (20) and said lower portion (23) of said at least one of said conductors (6) are laterally offset by approximately 0.98 mm.

10. An electrical connector as set forth in claim 8 or 9 wherein centerlines of said at least one conductor (6) and an adjacent conductor (4) are laterally offset by approximately 1.04 mm.

11. A method of manufacturing an electrical connector (10), comprising the steps of:

forming a first plurality of conductors (1,3,5,7) having a contact area (20) and a raised portion (22);
forming a second plurality of conductors (2,4,6,8) having a contact area (20) and a lower portion (23);
positioning said first and second pluralities of conductors (1,2,3,4,5,6,7,8) in an array within a connector housing (14) with the contact area (20) of each said conductor being located in a first plane, said raised portions (22) of said first plurality of conductors (1,3,5,7) being located in a second plane, and said lower portions (23) of said second plurality of conductors (2,4,6,8) being located in a third plane, where said first, second and third planes are offset from one another.

12. The method as set forth in claim 11 further comprising the steps of:

forming at least one (3,5) of the first plurality of conductors with the contact area (20) and the raised portion (22) thereof being laterally offset from one another; and
forming at least one (6) of the second plurality of conductors with the contact area (20) and the lower portion (23) thereof being laterally offset from one another.

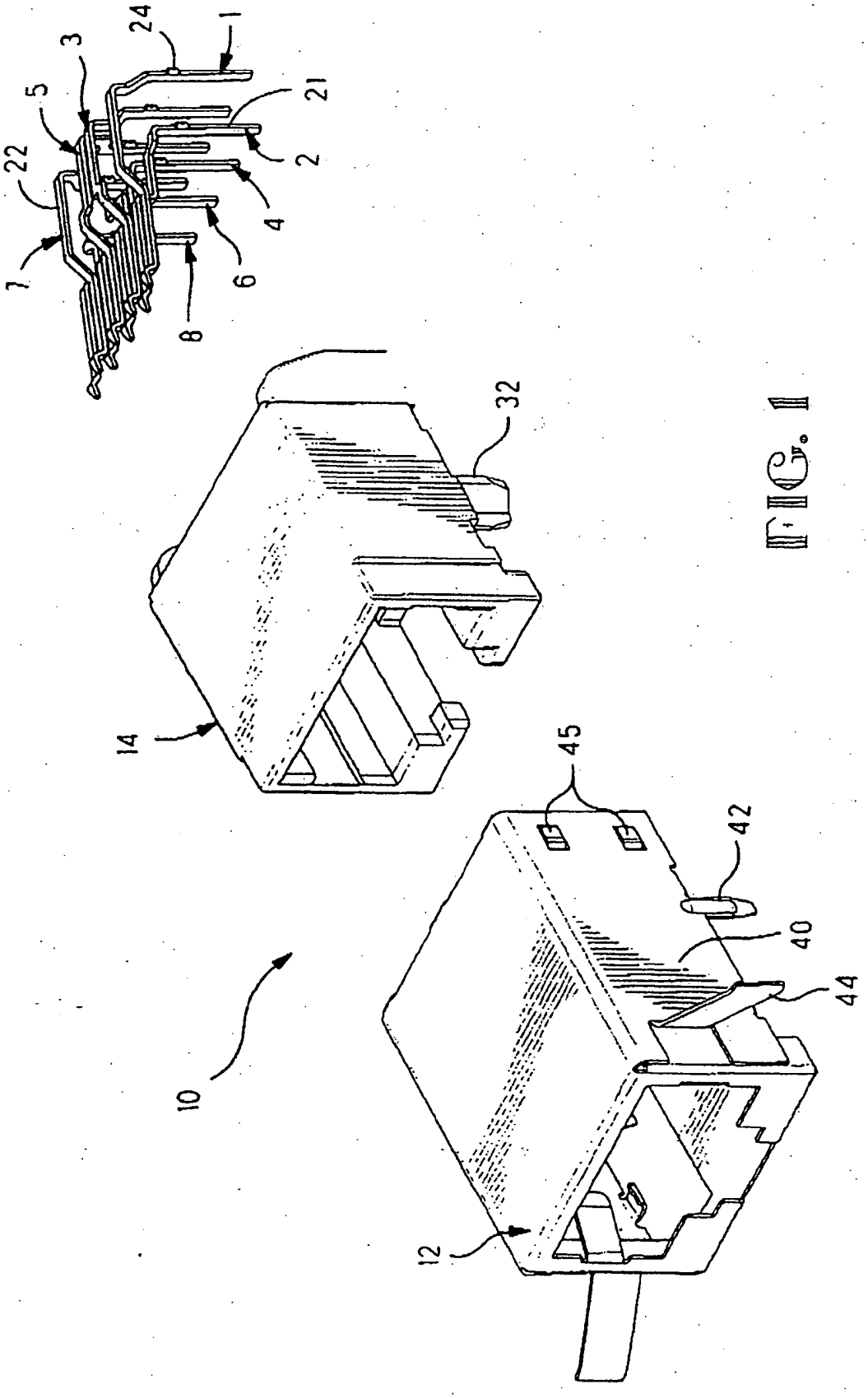

FIG. 1

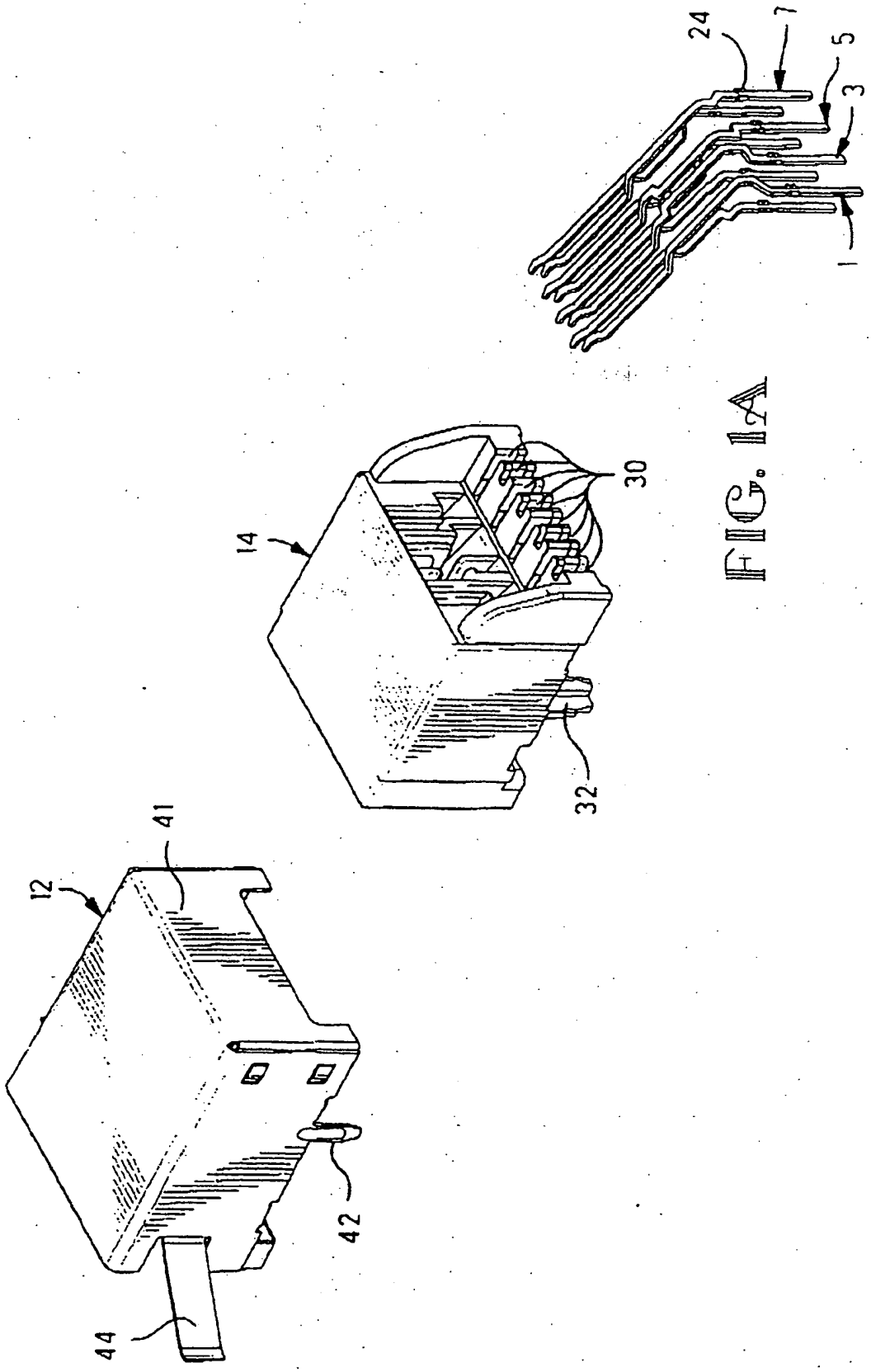

FIG. 1A

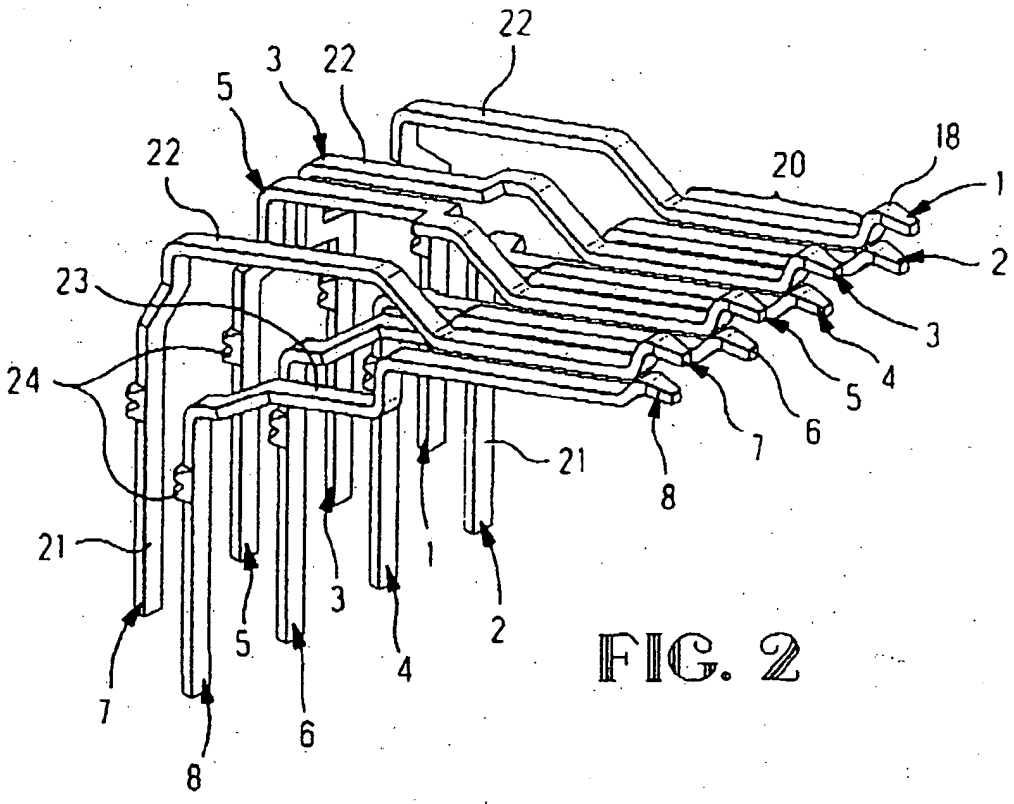
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FIG. 2

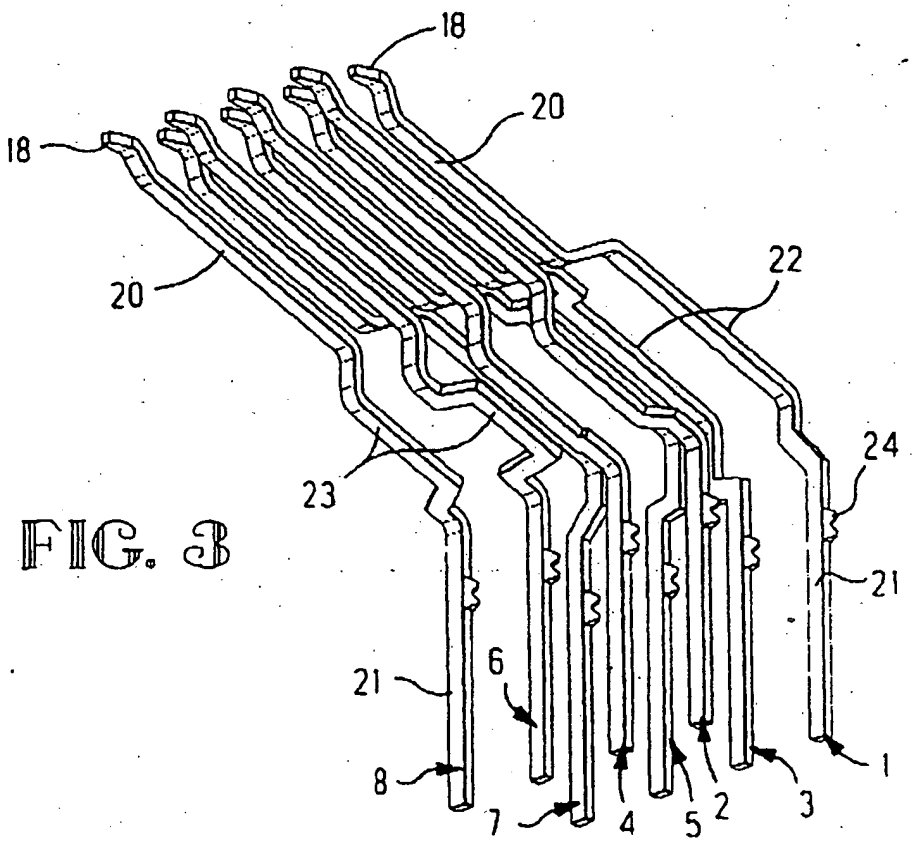
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FIG. 3

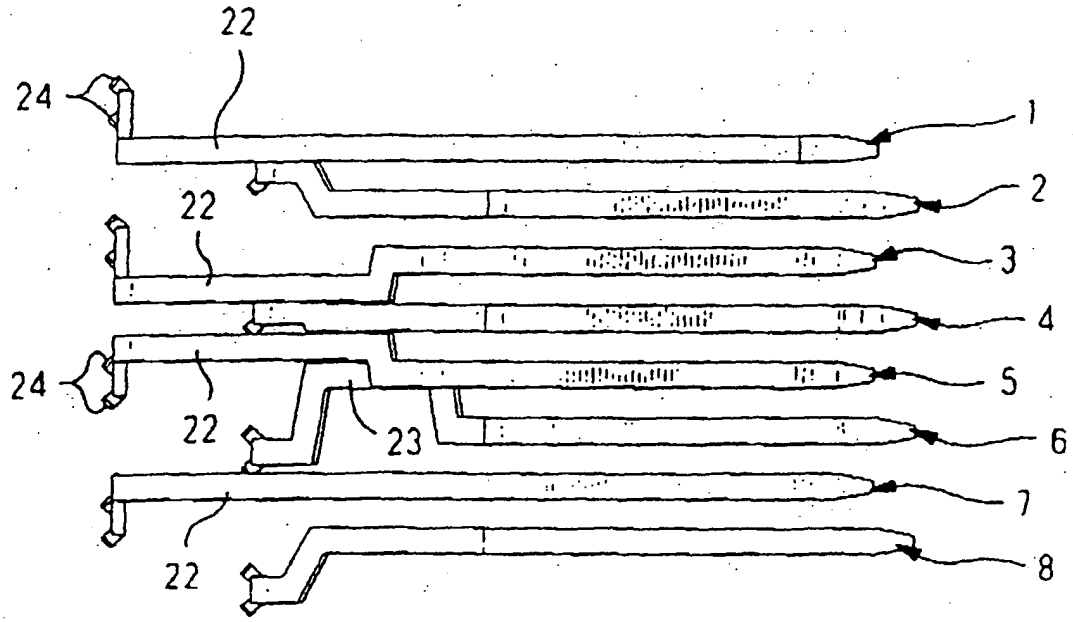

FIG. 4

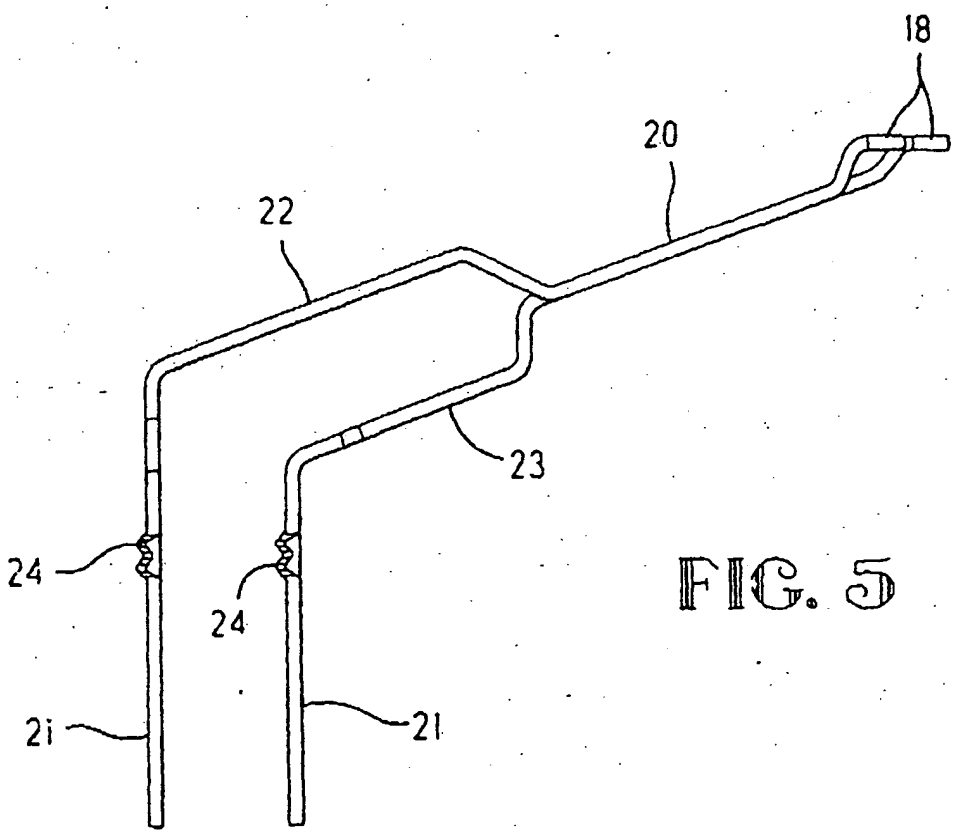

FIG. 5